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ABSTRACT

The educational irony of this century has been to acquaint young people with the great ideas and achievements of science and then to deny them any insights into the social arrangements which can make these achievements of recognizable benefits to mankind. A science based culture cannot be understood by the separate study of disciplines, each with its own body of technical information and autonomous theories. The science knowledge of most worth for general education is that which reflects the spirit of science, and the social, the cultural, the technological and the humane phases of the scientific enterprise. (Author/SBE)

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THE CHANGING PHILOSOPHY OF SECONDARY SCHOOL SCIENCE

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Early in the 1950's it became apparent that the secondary school science curriculum was essentially meaningless for understanding modern science. The subject matter was frequently outdated, often as much as a half century, and courses were overloaded with trivial information of little importance for comprehending today's science. Furthermore, in an attempt to provide 'coverage' of a field, the textbook treatment of a topic became shallower as the complexity of the ideas involved increased. One solution to the learning problem was to set 'key' ideas in bold-faced type to indicate they should be memorized because of their importance. The high school graduate more often than not described his science courses in terms of what he had forgotten rather than what he remembered.

Science courses differed from other subjects in high school because here one did experiments. For the most part a routine was especially designed to provide a 'right' answer if the student followed directions, and little else was expected of him except to 'turn in' his write-up. The write-up began with the statement of a problem and ended with a 'conclusion' (more accurately, a summary of the observations). In this way the student was expected to acquire an understanding of something called the 'scientific method.'

Late in the 1950's a major effort was initiated to reform the teaching of science in high schools. The task, placed in the hands of research scientists, included the directive "to improve course content." After examining the subject matter of typical courses in wide use at the time, the separate curriculum committees decided to develop new programs of biology, chemistry, and physics. Each curriculum project operated under the assumption that the new courses should represent a more rigorous treatment of science and display it in the way it is known to research scientists. Thus, the student would obtain a valid picture of the <u>science</u> of biology, chemistry or physics. To know the theoretical, investigative, and conceptual basis of a particular discipline became the primary goals of the new science.

To achieve the new goals of science teaching, a few major conceptual ideas, central for understanding a discipline, became the core of each curriculum. Through an in-depth exploration of these concepts young people would acquire a notion of what scientific insight means. The laboratory experiments designed for the new courses consisted of 'open-ended' investigations which afforded practice in scientific inquiry. Keeping the new courses faithful to the disciplines of science meant omitting the majority of technological and applied topics found in traditional science textbooks. Here again, the assumption was made that science taught in the way scientists understand it 'would make it inherently interesting' for the non-scientist. All too briefly, this represents the general tone of secondary school science improvement efforts over the past dozen years.[1]

The science curriculum reform movement of the 1960's brought forth a number of innovative ideas, for example, improvements in curriculum design and instructional materials. The importance of teaching style in relation to instructional objectives gained recognition as did the need for students to have a greater responsibility in thinking through science oriented problems on their own. But for all these gains and others, the effectiveness of the new courses in terms of increasing student interest in science and developing an appreciation of the scientific enterprise as it relates to the intellectual and material progress of mankind has been disappointing, if not negative. Decreasing enrollments in

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[1] For the reader who desires a detailed description of this period see Hurd, Paul DeHart. New Directions in Teaching Secondary School Science. Chicago: Rand McNally, 1969. Paper.

science courses in high school and college, as well as the current distrust of scientists, are illustrative of the negative impact.

The social and cultural conditions which gave rise to the science curriculum improvement projects of the 1960's are not the conditions of 1970. The emerging problems that concern both scientists and citizens suggest that again we need to reexamine the goals of science teaching. Science has now become broadly integrated into all phases of our culture. A close partnership has developed between science and the economic, social, and political issues of our time. The conditions of science also show change; science and technology being symbiotic, ferment pressures to make the scientific researcher more socially responsible and there is a demand to assess the potential impact of technological developments before widespread introduction into the economy. These pressures represent the concerns of the common man who somehow feels science and technology have little concern for him as a human being. Ironically, he sees little connection between scientific achievements and the possibilities for personal, cultural and social betterment. He does not recognize the potential science holds for the whole of life and how it can affect the future of man; nor does he appreciate the history of modern science and its influence upon

American civilization from the beginning. Most of all the average citizen does not know what science is, nor does he understand the requirements for effective living in a modern scientific-technological-industrial society. It is in each of these ways that the science teaching of the 1960's has fallen short of an appropriate education in science for the non-scientist.

Science Education for the 1970's

The broad goal of science teaching for the 1970's needs to go beyond the restrictive context of the special disciplines and consider science in relation to the affairs of mankind, the actualities of the "real" world, and the human condition. The scientific enterprise becomes meaningful for the common man only in a cultural and social context. The task of general education is to make it possible for the student to bridge the gap between knowledge in being and knowledge in action. Knowledge lacks significance at any time unless it can be applied to problems or used to seek new goals. The scientific researcher applies his knowledge to advance the frontier of his discipline; the nonspecialist wishes to employ science information to cope with personal and social problems in a way that will make a difference in human living.

Looking back to the 1960's we find considerable emphasis in all the new curricula on developing skills of scientific inquiry. Problems for the laboratory and field require students "to think like a scientist and to use the strategies of scientific investigation." A closer examination, however, reveals that problems which students face are those of life; they are 'real,' they are complex and not subject to simplification or to the precise controls of the laboratory. Out of class the student must face science-social problems, and answers to these always involve a consideration of people. Any satisfactory solution to these problems depends upon treating data in a <u>qualitative</u> fashion with an emphasis upon <u>valuating</u> information. The problem-solving process is essentially one of decision making. Whatever answer is formed depends as much on politics, consensus, trade-offs, personal choice, group dynamics, follow through, feedback, and the weighing of advantages as it does on reliable information. The worthiness of an answer relies more on the contribution it makes to significant social action than on whether it is consistent with a relevant theory of science. This does not mean the student behaves in an irresponsible fashion; we expect his thinking to be disciplined and rational, using knowledge from science for making as reliable judgments as possible.

Social problems based in science are seldom confined to a single discipline but have overlaps not only within science but with other fields of human endeavor which may include the arts, philosophy, religion and the behavioral sciences. This condition suggests the need for a greater inter-penetration of subject matter within the sciences and the establishment of 'bridges' between the sciences and other fields of learning. This is especially important if we expect the student to become a better citizen in the sense of being more informed, more concerned, and more competent to reach science-social decisions. In another way, this is essential if we expect to bring science into the general culture so that its intellectual, aesthetic and social benefits may be recognized and utilized.

The tendency for schools to present subjects in discipline-bound courses keeps us from realizing the full potential of any field of knowledge and places the student in a state of paralyzing ignorance and continuous frustration about how to deal with the very problems that concern him most. C. P. Snow, in his remarks to the U. S. Committee On Science and Astronautics, described the situation this way:

> "We need to know, more exactly, how we are living here and now. We are ignorant of the social life around us; we are more ignorant than is wise or safe or human. And

this is where I come back to a plea for the mix-up-ness of scientists, politicians, administrators, all the others--doctors, priests, citizens of good-will--who are not cut off from our common humanity."

Agnes E. Meyer, in her book on Education for a New Morality, comments in a similar fashion:

"We need a prophet of a 'Brave New World,' not like Huxley's, but one that is really brave and really new. But before these geniuses can appear upon the scene, the experts in the natural and social sciences, together with the humanists, must lay the groundwork by the same cooperative endeavor that animated the various scientific experts who split the atom. In short, we must achieve a humanism that is truly scientific and a science that is truly humane."

Each of these statements represent the prescription for the 1970 phase of science curriculum development.

It seems evident we should extend the goals of science teaching to include a component that demonstrates how science can be brought into a stronger, a more effective, and a more realistic human relationship. This does not mean that the virtues, processes and concepts of science are to be taught with lesser meaning but that they are taught in a societal context and in relationship to other disciplines. A science based culture cannot be understood by the separate study of disciplines, each with its own body of technical information and autonomous theories. The science knowledge of most worth for general education is that which reflects the spirit of science, the social, the cultural, the technological and the humane phases of the scientific enterprise. The educational irony of this century has been to acquaint young people with the great ideas and achievements of science and then to deny them any insights into the social arrangements which can make these achievements of recognizable benefit to mankind.

A general education in the sciences should make it possible for students:

--to recognize that science reflects as well as stimulates the course of social and economic development, and thus influences the progress of civilization.

--to recognize that technological and economic developments are dependent upon the value system of a society which is supportive of scientific research: there is an interaction between social and intellectual values and the conditions which support science and technological endeavors.

--to recognize that the future potential of our civilization is likely t rest more with scientific than technological achievements.

--to recognize that social and economic changes may be necessary to keep pace with and to enhance scientific and technological developments.

--to recognize that while science reflects the values of a culture, it also influences the philosophical and humanistic ideas contained within the culture.

--to appreciate science for the intellectual stimulus it provides as man seeks to understand his natural environment and to improve his own condition.

--to recognize that a rational solution for many social, economic and political problems is feasible only in the context of science and technology.

These goals are illustrative of the changing educational philosophy for the teaching of science in secondary schools. There is much more to be thought through to bring these goals into their fullest meaning for this period of science curriculum development.

It is quite proper that young people get a conceptually coherent presentation of a scientific discipline in a course; but if they fail to become acquainted with the interplay of issues and controversies that led to this knowledge, then they have been indoctrinated. And if they have not been given an insight into how this knowledge contributes to the intellectual culture of our times and to the resolution of social and technological problems, they have spent their class hours on unrealistic activities. It is time that the teaching of science be moved from a rigid discipline orientation and brought into collaboration with society and the humane arts.